Solidworks Tutorial: Shear Force on a Bolted Connection

Created by Menooa Avrand, last updated on Dec 04, 2025 • 8 minute read

By Menooa Avrand **04 Aug 2025**

Feel free to contact me if you need any clarification.

Purpose

There is a lot of undocumented torque data from previous vehicles, so this tool can help standardize and record proper install torques moving forward.

Learn how to simulate bolted connections in SolidWorks to evaluate whether your selected bolts can withstand a given load case. This tutorial uses two simple plates to walk through the workflow and demonstrate how to properly model bolted joints using SolidWorks Simulation.

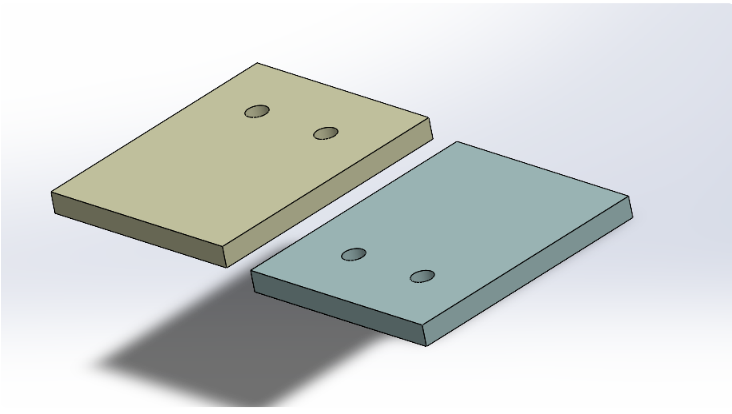
⚠️ Important: To avoid using an overestimated or maximum preload—which can significantly reduce the calculated Factor of Safety (FOS) for both bolts and interfacing parts—I've created a Bolt Preload Calculator to assist you with accurate preload selection. This tool will be used later in the tutorial.

Note: This calculator computes the recommended preload based on the material strength of the bolt, not the material your part is made of.

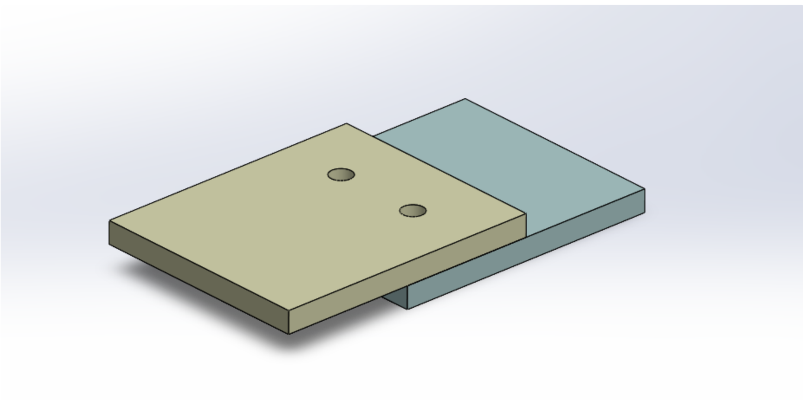
🔗 **Bolt Preload Calculator – Google Drive Link** (**Download and open in Excel**)

Procedure

1. Open your two desired interfacing parts into an assembly. (Top Plate | Bottom Plate)



2. Mate and constrain the two parts so they interface with one another as they should.

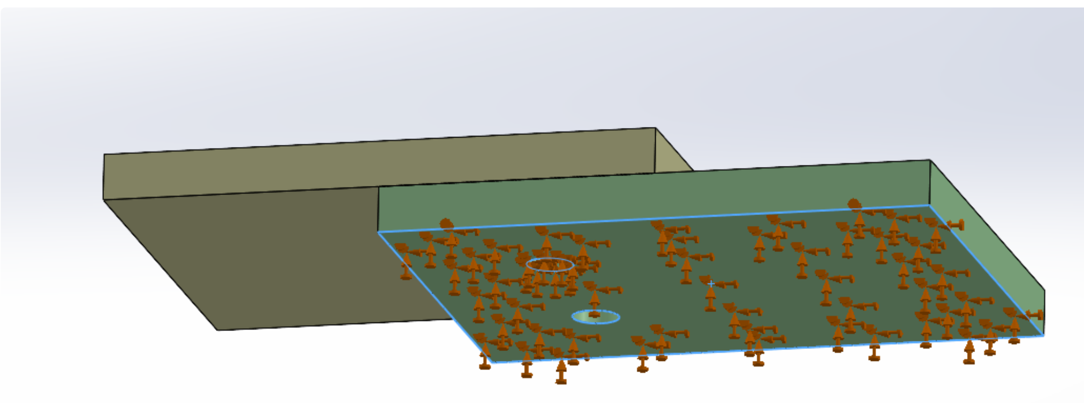


In this example: Concentric mate at bolt holes and Coincident mate two interfacing surfaces.

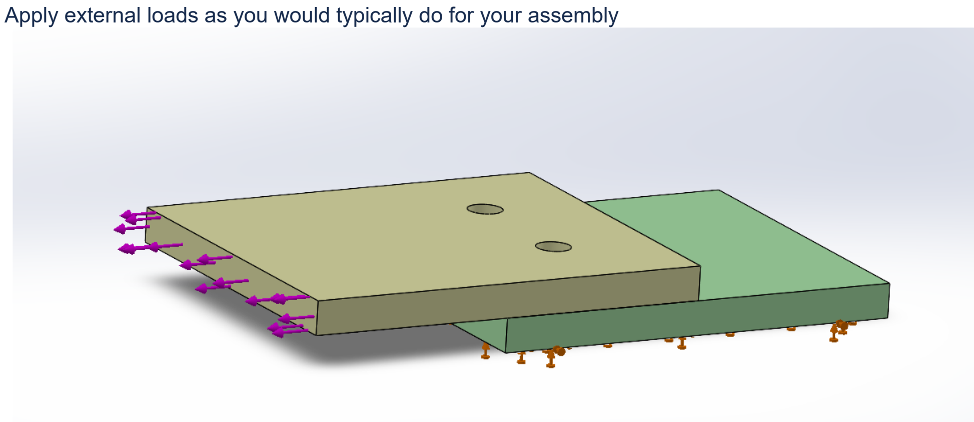
3. Start a new simulation study | Simulations → New Study → Static
4. Select and apply the material of the two interfacing parts

In this example: Selected 7075 T6

5. Apply fixtures as you would typically do for your assembly, but ensure there is a fixed geometry on the face, which the nut will interface with.

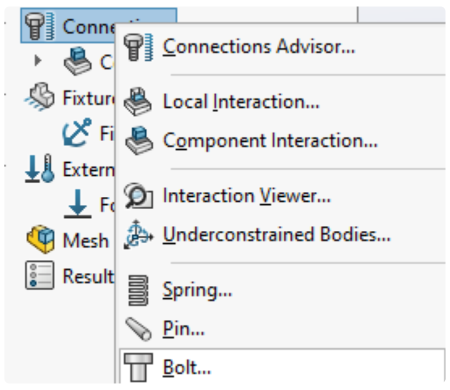


6. Apply external loads as you would typically do for your assembly

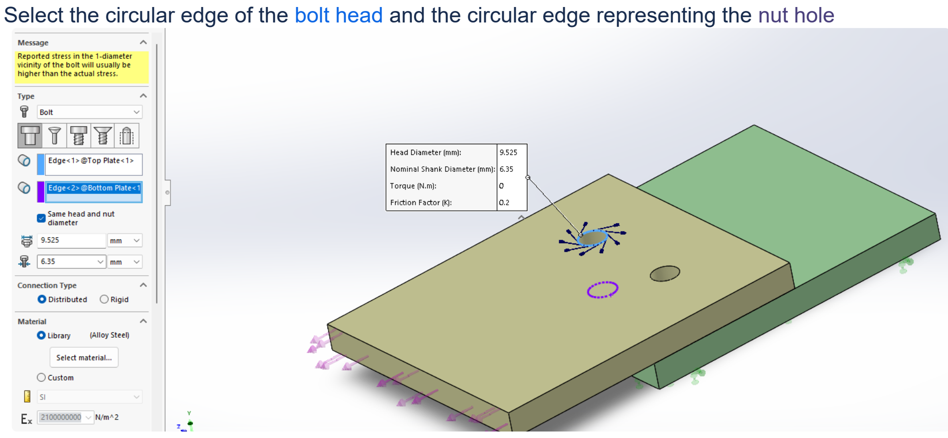


In this example, we have a 200N force onto the face seen above

7. Now we will move on to the bolt connection section
   a. Right click connections → Select Bolt...



b. Select the circular edge of the bolt head and the circular edge representing the nut hole



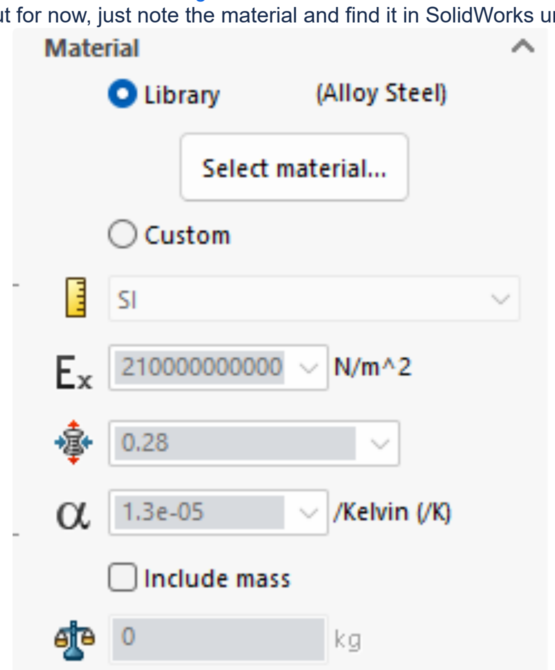
c. **Connection Type** (Choose Distributed Connection)

The distributed connection produces more realistic stress and displacement fields at a bolt's head and nut contact areas.

The rigid connection produces stress hot spot areas inside the head and nut regions of the connected components, because rigid bars introduce high stiffness. A distributed connection eliminates these high stresses.

d. **Material**
From purely the geometry of the holes, suppose we choose the following bolt from McMaster.
Zinc Yellow-Chromate Plated Hex Head Screw Grade 8 Steel, 1/4"-28 Thread Size, 3/4" Long
From the McMaster page, we can gather alot of valuable information, but for now, just note the material and find it in SolidWorks under (Select Material).

Head Type	Hex
Drive Style	External Hex
System of Measurement	Inch
Thread Direction	Right Hand
Thread Size	1/4"-28
Screw Size Decimal Equivalent	0.25"
Thread Type	UNF
Thread Fit	Class 2A
Length	3/4"
Threading	Fully Threaded
Thread Spacing	Fine
Head	
Width	7/16"
Height	5/32"
Fastener Strength Grade/ Class	Grade 8
Material	Steel
Finish	Zinc Yellow-Chromate Plated
Tensile Strength	150,000 psi
Hardness	Rockwell C33
Specifications Met	ASME B18.2.1, SAE J429
RoHS	RoHS 3 (2015/863/EU) Compliant
REACH	REACH (EC 1907/2006) (01/21/2025, 247 SVHC) Compliant
DFARS	Specialty Metals Compliant (252.225-7009)
Country of Origin	Canada
USMCA Qualifying	No
Schedule B	731815.9000
ECCN	EAR99



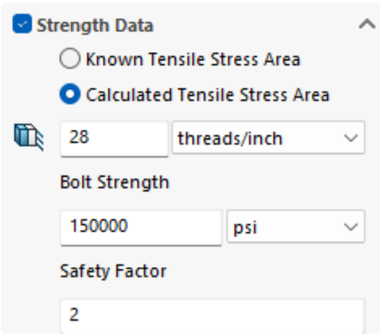
e. **Strength Data**
This is essentially the main tab that will allow us to compute the FOS of our bolts.'
i. Enable Strength Data
ii. Select Calculated Tensile Stress Area
iii. Input the Threads per Inch (From McMaster)
In this example it is 28 threads per inch

Head Type	Hex
Drive Style	External Hex
System of Measurement	Inch
Thread Direction	Right Hand
Thread Size	1/4"-28
Screw Size Decimal Equivalent	0.25"
Thread Type	UNF
Thread Fit	Class 2A
Length	3/4"
Threading	Fully Threaded
Thread Spacing	Fine
Head	
Width	7/16"
Height	5/32"
Fastener Strength Grade/ Class	Grade 8
Material	Steel
Finish	Zinc Yellow-Chromate Plated
Tensile Strength	150,000 psi
Hardness	Rockwell C33
Specifications Met	ASME B18.2.1, SAE J429
RoHS	RoHS 3 (2015/863/EU) Compliant
REACH	REACH (EC 1907/2006) (01/21/2025, 247 SVHC) Compliant
DFARS	Specialty Metals Compliant (252.225-7009)

iv. Input the Bolt Strength (From McMaster)
In this example it is 150,000 psi

Head Type	Hex
Drive Style	External Hex
System of Measurement	Inch
Thread Direction	Right Hand
Thread Size	1/4"-28
Screw Size Decimal Equivalent	0.25"
Thread Type	UNF
Thread Fit	Class 2A
Length	3/4"
Threading	Fully Threaded
Thread Spacing	Fine
Head	
Width	7/16"
Height	5/32"
Fastener Strength Grade/ Class	Grade 8
Material	Steel
Finish	Zinc Yellow-Chromate Plated
Tensile Strength	150,000 psi
Hardness	Rockwell C33

v. Safety Factor
This is the desired FOS value.... if the calculated FOS is under this desired value, it will highlight the bolt that fails this criteria in red
(Depends on your load case, but suppose we select 2 FOS for this scenario)



f. **Preload**

The preload tab is where we need to utilize the Bolt Preload Calculator
V3_Bolt_Torque_Preload_Calculator_Modified (Note: this is a "macro enabled" Excel so you might need to Enable/Accept/Trust it in the settings)
To calculate the preload you will need to select 5 inputs into the calculator

i. **Bolt Material # from Material Table**

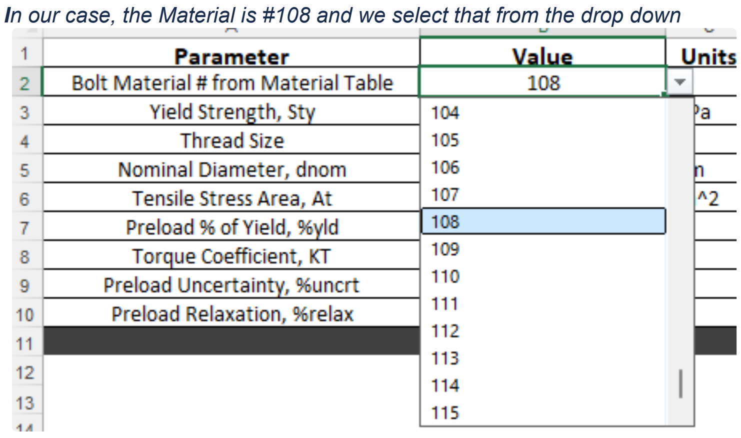
Select the Material Table sheet on the bottom of the Excel
Find the material of the bolt in this library.

Head Type	Hex
Drive Style	External Hex
System of Measurement	Inch
Thread Direction	Right Hand
Thread Size	1/4"-28
Screw Size Decimal Equivalent	0.25"
Thread Type	UNF
Thread Fit	Class 2A
Length	3/4"
Threading	Fully Threaded
Thread Spacing	Fine
Head	
Width	7/16"
Height	5/32"
Fastener Strength Grade/ Class	Grade 8
Material	Steel
Finish	Zinc Yellow-Chromate Plated
Tensile Strength	150,000 psi
Hardness	Rockwell C33
Specifications Met	ASME B18.2.1, SAE J429
RoHS	RoHS 3 (2015/863/EU) Compliant
REACH	REACH (EC 1907/2006) (01/21/2025, 247 SVHC) Compliant
DFARS	Specialty Metals Compliant (252.225-7009)
Country of Origin	Canada
USMCA Qualifying	No
Schedule B	731815.9000
ECCN	EAR99

There are numerous ways to classify the bolt but in our example we will use the Specs met (**SAE J429**) and the Faster grade of **Grade 8**

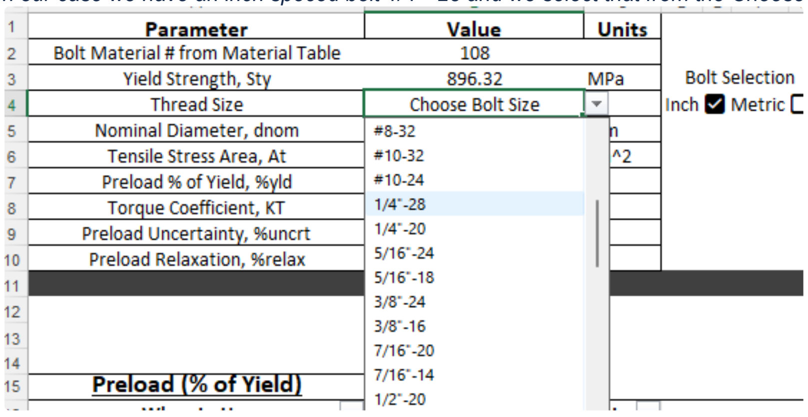
107	105	Nitronic 50	As hot-rolled (Bar, Profile, <= 2.0 in)	Stainless Steel	105,000	135,000	20.00%
108	106	Nitronic 50	Cond A (Bar, Profile, All Sizes)	Stainless Steel	55,000	100,000	35.00%
109	107	Nitronic 60	Cond A (Bar, Profile, All Sizes)	Stainless Steel	50,000	95,000	35.00%
110	108	SAE J429	Grade 8 (Bolts, Screws, Studs, 1/4 - 1-1/2 in)	Carbon/Alloy Steel	130,000	150,000	12.00%
111	109	SAE J429	Grade 5 (Bolts, Screws, Studs, 1/4 - 1 in)	Carbon/Alloy Steel	92,000	120,000	14.00%
112	110	SAE J429	Grade 5 (Bolts, Screws, Studs, >1/4 - 1-1/2 in)	Carbon/Alloy Steel	81,000	105,000	14.00%
113	111	SAE J429	Grade 1 (Bolts, Screws, Studs, 1/4 - 1-1/2 in)	Carbon/Alloy Steel	36,000	60,000	18.00%

In our case, the Material is #108 and we select that from the drop down



ii. **Thread Size**

First select the bolt selection unit, either Inch or Metric
In our case we have an inch speced bolt 1/4" -28 and we select that from the Choose Bolt Size drop-down



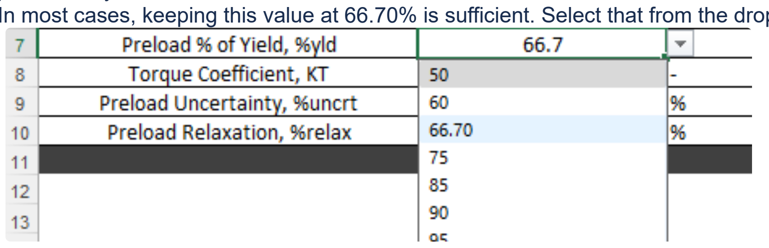
iii. **Preload % of Yield,**

There is a table in the Excel that explains the use scenario

Preload (% of Yield)

When to Use	Preload (% of Yield)	Notes
Conservative, moderate/variable loads	50%	Shigley/Lindeburg recommendation
Balanced preload, general critical joints	60%	Safer with slightly better clamping
Rule of thumb, general use	66.70%	Common default, good balance
High preload, static-heavy joints	75%	Only if ductility & design allow
Max preload (proof strength)	85%	Beyond this risks plastic deformation
Avoid unless specialized application	>85%	Use only with testing or FEA

The % of yield is essentially the FOS of the preload w.r.t the bolt material. For example selecting 50% will ensure your preload is cannot drop your bolt FOS lower than 2.0. 100% will compute the preload so your bolt is near/at FOS 1.0
In most cases, keeping this value at 66.70% is sufficient. Select that from the drop-down



iv. **Torque Coefficient**

Similarly, there is a table in the Excel that dictates the value based on the bolt condition

Torque Coeffienct	
Bolt Condition	K_T
Nonplated, black finish	0.3
Zinc-plated	0.2
Lubricated	0.18
With Anti-Seize	0.12

Reference Shigley

In our example, we see the bolt is zinc plated

Equivalent	
Thread Type	UNF
Thread Fit	Class 2A
Length	3/4"
Threading	Fully Threaded
Thread Spacing	Fine
Head	
Width	7/16"
Height	5/32"
Fastener Strength Grade/ Class	Grade 8
Material	Steel
Finish	Zinc Yellow-Chromate Plated
Tensile Strength	150,000 psi
Hardness	Rockwell C33
Specifications Met	ASME B18.2.1, SAE J429
RoHS	RoHS 3 (2015/863/EU) Compliant
REACH	REACH (EC 1907/2006) (01/21/2025, 247 SVHC) Compliant

Therefore, we select 0.2 from the drop-down

8	Torque Coefficient, KT	0.2	
9	Preload Uncertainty, %uncrt	0.3	%
10	Preload Relaxation, %relax	0.2	%
11		0.18	
12		0.12	

v. **Preload Uncertainty**

Lastly we select the %accurany based on how we intend to tighten the bolt when we will assemble these parts in the future.
Similarly, there is a table in the Excel that dictates the value based on method.

33	Preload Uncertainty	
34	Tightening Method	Accuracy
35	By feel	±35%
36	Torque wrench	±25%
37	Turn-of-the-nut	±15%
38	Load indicating washer	±10%
39	Bolt elongation	±3-5%
40	Strain gages	±1%
41	Ultrasonic sensing	±1%
42	Reference Machinery's Handbook	

For this part we will assume we will use a torque wrench so we will select 25% from the drop down

9	Preload Uncertainty, %uncrt	25	
10	Preload Relaxation, %relax	1	%
11		3	
12		5	
13		10	
14		15	
15	Preload (% of Yield)	25	

vi. **Results**

Parameter	Value	Units
Bolt Material # from Material Table	108	
Yield Strength, Sty	896.32	MPa
Thread Size	1/4"-28	-
Nominal Diameter, dnom	6.35	mm
Tensile Stress Area, At	0.2347	cm^2
Preload % of Yield, %yld	66.7	%
Torque Coefficient, KT	0.2	-
Preload Uncertainty, %uncrt	25	%
Preload Relaxation, %relax	10	%

Bolt Selection
Inch ☑ Metric ☐

Results

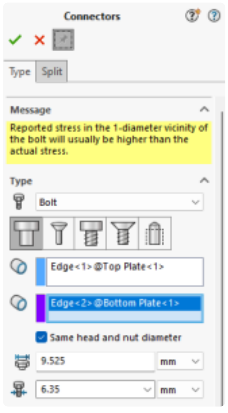
Preload Force, FPL (N)	Install Torque, T (N·m)	% of Yield Strength	Torque Coefficient, KT
14,030	17.8176	66.7	0.2

The nominal value is the design target, and the min and max values account for preload uncertainty and relaxation.

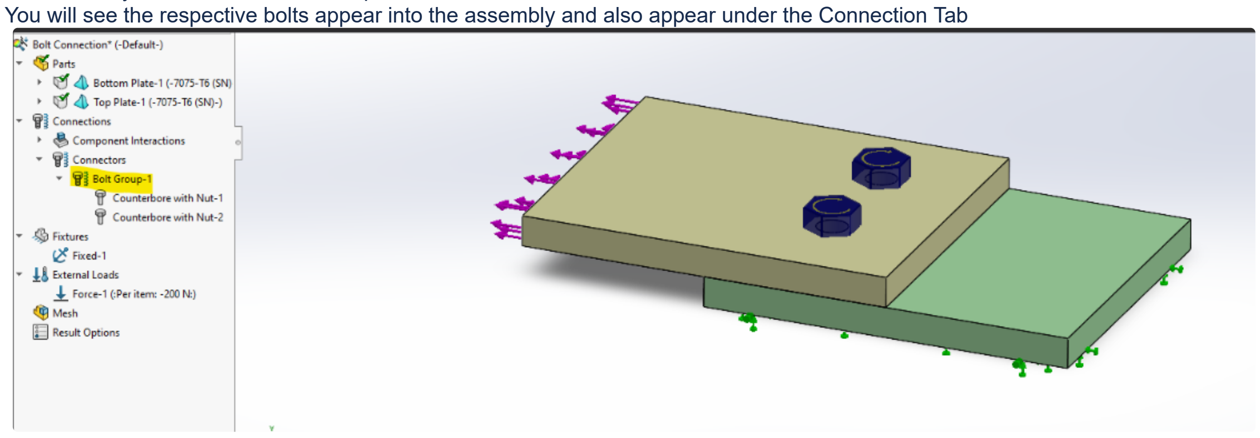
	Nominal	Minimum	Maximum
Preload Force (N):	14,030	9,119	17,537
% of Yield Strength	66.7	43.355	83.375
Install Torque, T (N·m)	17.8176	11.5814	22.2719

From the calculator, we obtain the Nominal install torque of 17.8 Nm, which we can input into SolidWorks. We can also choose any installation torque value between the minimum and maximum values, which accounts for the preload uncertainty and the relaxation.

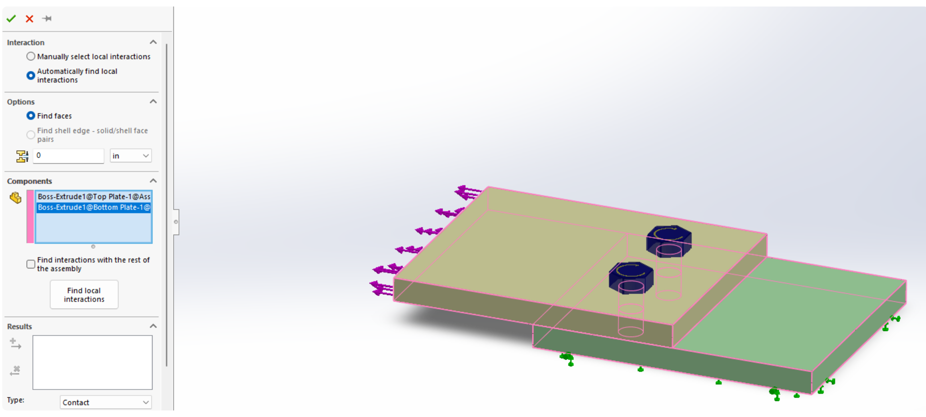
g. Lastly, we need to do this for each bolt in our assembly.
If the bolts are the same spec and size you can simply enable the Keep Visible pin, hit the Green check OK, then select any other bolt holes instead of having to re-input all the values again



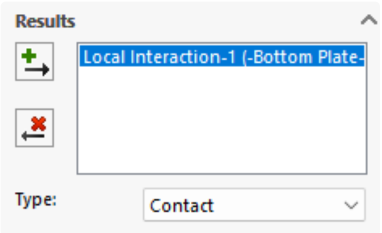
Once done, you can uncheck the Keep Visible Pin and close the Bolt tab
You will see the respective bolts appear into the assembly and also appear under the Connection Tab



8. Lastly we need to establish the local connection (how the parts interface with eachother within the assembly)
Right click Connection → Local Interaction → Automatically find Local Connections
In this example we select the two plates as the components

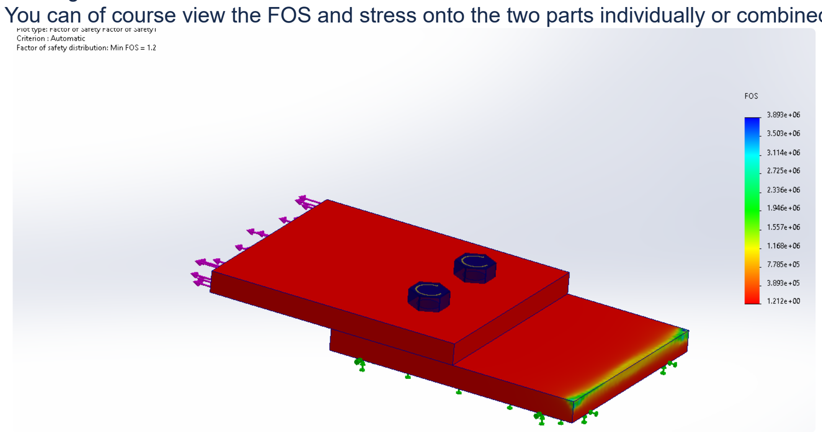


Click Find Local Interactions



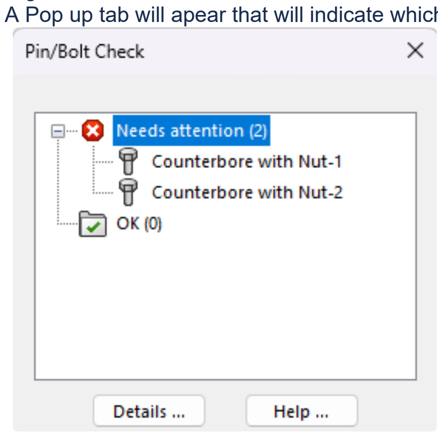
(Note: they are in contact in this example, but we can select Bonded|Free|Contact based on the way we deem the two parts would interact ..... Contact is usually more accurate but slower to run)
Hit OK and Yes to the pop-up window.

9. We can now mesh and simulate as we typically would do for any FEA sim
10. Viewing Results
    You can of course view the FOS and stress onto the two parts individually or combined (it selects the lower FOS value)

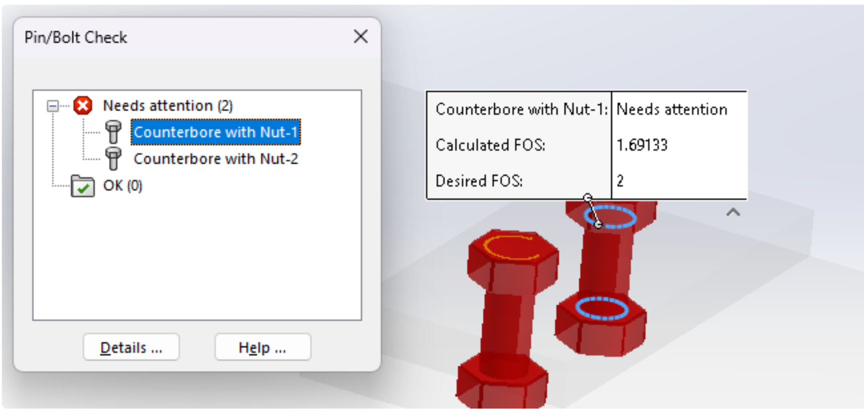


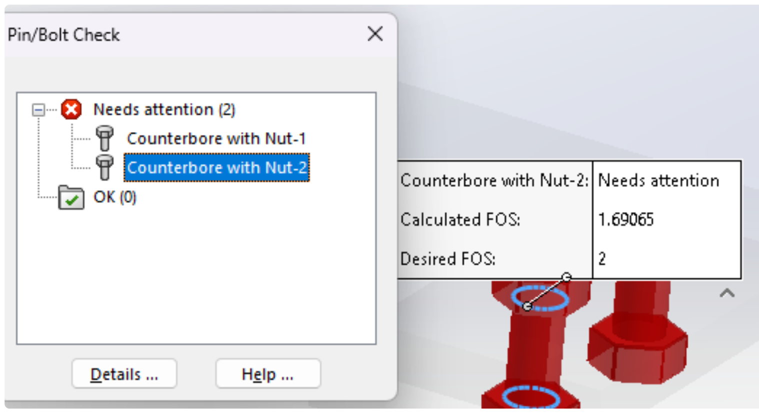
But we care to see if the bolts can handle this shear load.....

a. Right click Results → Define Pin/Bolt Check Plot → Hit OK (green checkmark)
b. A Pop up tab will apear that will indicate which bolts passed our desired FOS and which are below

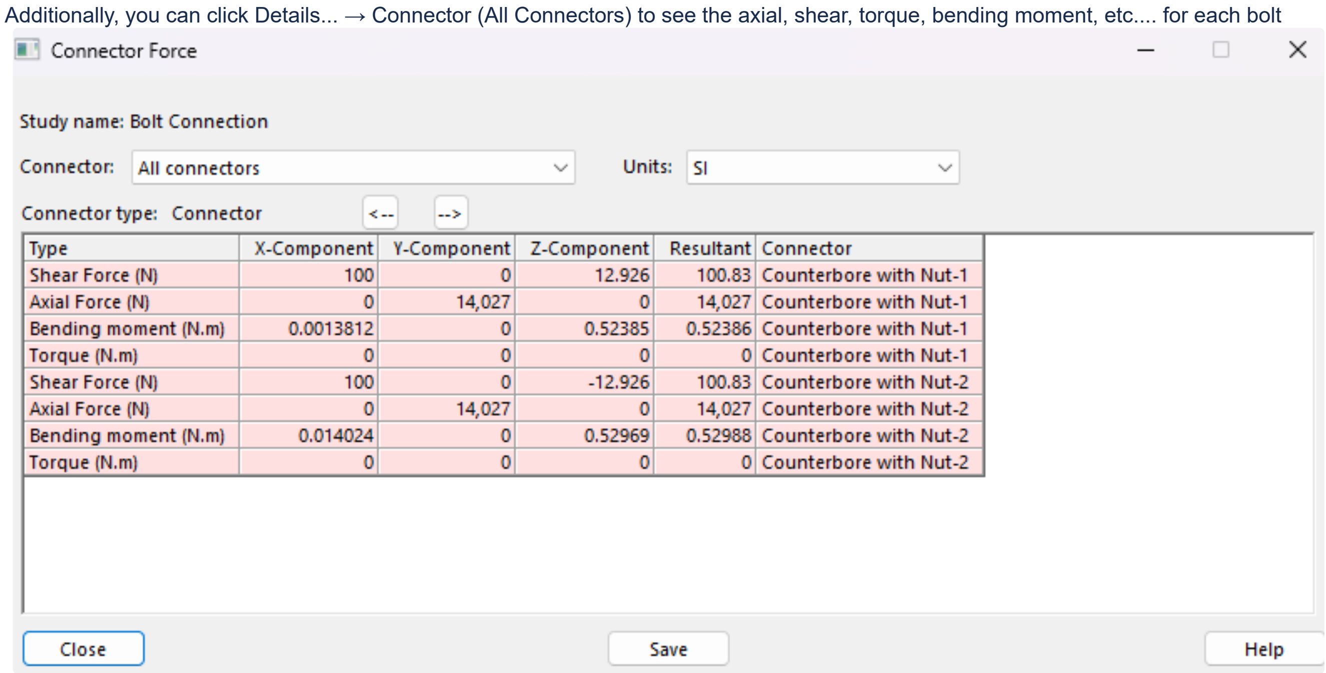


c. We can click on each bolt to see the FOS on each bolt....





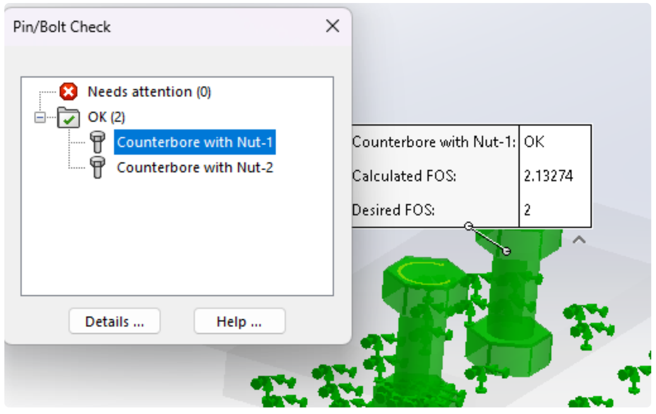
d. Additionally, you can click Details... → Connector (All Connectors) to see the axial, shear, torque, bending moment, etc.... for each bolt



Type	X-Component	Y-Component	Z-Component	Resultant	Connector
Shear Force (N)	100	0	12.926	100.83	Counterbore with Nut-1
Axial Force (N)	0	14,027	0	14,027	Counterbore with Nut-1
Bending moment (N.m)	0.0013812	0	0.52385	0.52386	Counterbore with Nut-1
Torque (N.m)	0	0	0	0	Counterbore with Nut-1
Shear Force (N)	100	0	-12.926	100.83	Counterbore with Nut-2
Axial Force (N)	0	14,027	0	14,027	Counterbore with Nut-2
Bending moment (N.m)	0.014024	0	0.52969	0.52988	Counterbore with Nut-2
Torque (N.m)	0	0	0	0	Counterbore with Nut-2

e. In this case scenario, the bolts had an FOS of 1.69; thus, the selected bolts specs do not meet our desired 2.0 FOS.
   We can consider higher-grade bolts, different materials/or increasing the bolt diameter. Note: Either of these changes would require a recalculation of the preload using the calculator

   Note: A large preload can also decrease the FOS of our bolts, so choosing a value between the minimum and maximum install torques could help..
   For example, instead of the 17.8 Nm I selected 14 Nm which is still above our minimum value of 11.6 which resulted in the bolts to have an FOS of 2.13



This shows that although the calculator gives a nominal value, you should use your engineering judgment to determine if the install torque needs to be higher or lower than the nominal. For example, if the FOS result is 3.0 using the nominal install torque, but the part is expected to experience significant vibrations, we can use nylon locking nuts and/or apply a torque value closer to the maximum install torque to better resist the bolts loosening due to vibration.

- Use bolt series to choose the interfacing

No labels